Polish Notation

A + B	A + B +
A — B	A + B —
A × B	A + B ×
A ÷ B	A + B ÷

Enter first number: C A +

To operate on result: enter new number (if any) followed by operator.

Examples

A + B ÷ C × D	A + B + C ÷ D ×
sin (A + B)	A + B + ▲ +
log (A + B)	A + B + ▲ ×
arctan $\left(\frac{-A + B}{C}\right)$	A — B + C ÷ ▼ ÷
(A × sin(B × C)) ÷ D	B + C × ▲ + A × D ÷

Function Summary

$\log_{10}$	▲ ×	$\log_e$	▲ × 2 3 0 2 6 ×
alog_{10}	▼ ×	e	2 3 0 2 6 ÷ ▼ ×

	Radians	Degrees
sine	▲ +	5 7 3 ÷ ▲ +
cosine	▲ —	5 7 3 ÷ ▲ —
tangent	▲ ÷	5 7 3 ÷ ▲ ÷
arcsine	▼ +	▼ + 5 7 3 E 1 ×
arccosine	▼ —	▼ — 5 7 3 E 1 ×
arctangent	▼ ÷	▼ ÷ 5 7 3 E 1 ×

$\sqrt{A}$	A ▲ × 2 ÷ ▼ ×
$\sqrt[n]{A}$	A ▲ × n ÷ ▼ ×
A^B	A ▲ × B × ▼ ×

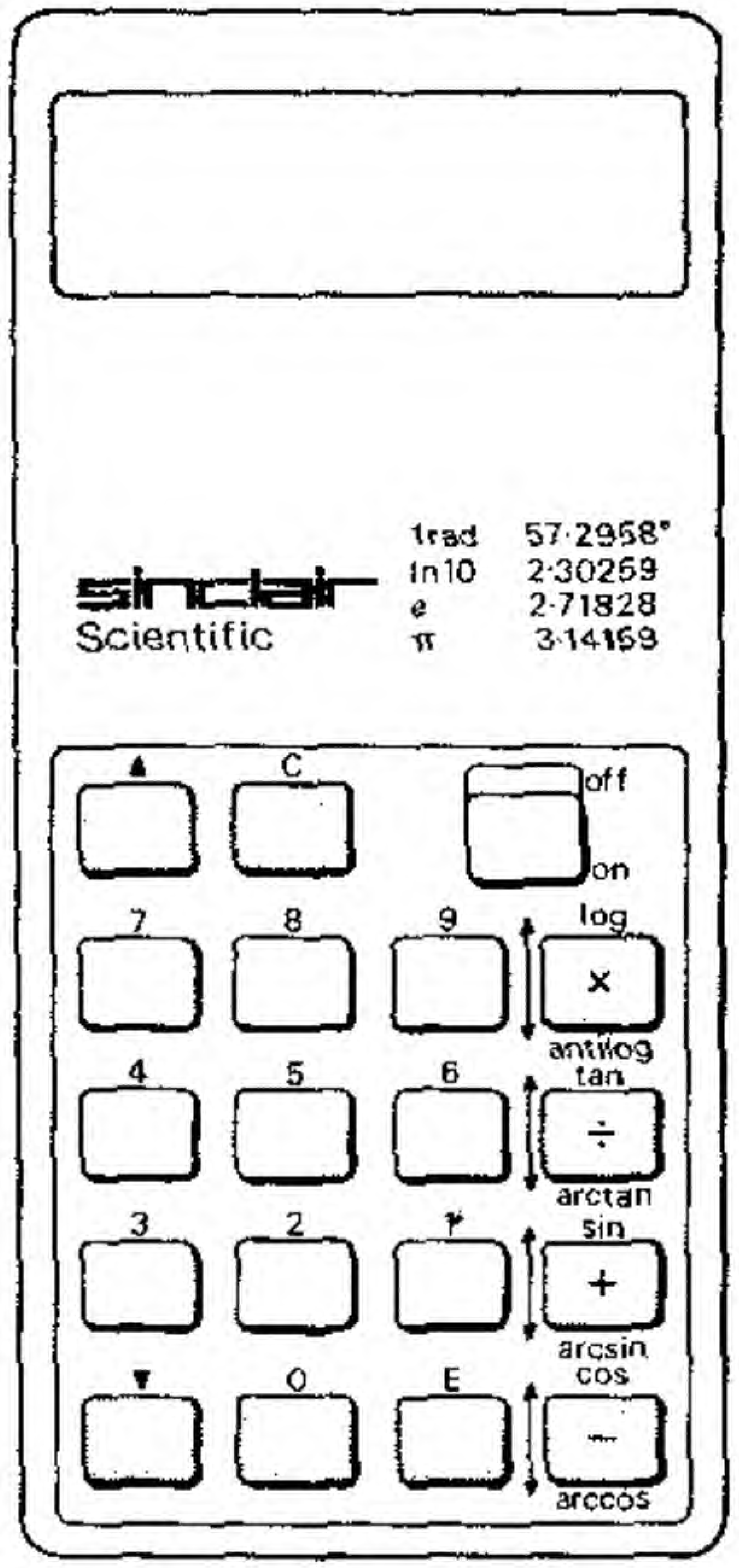
Technical Publication: [illegible]

Printed by W. Jefferson & Son Ltd., Ely

sinclair

Operating Instructions

SCIENTIFIC


sinclair
Scientific
1rad 57·2958°
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e 2·71828
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4
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6
÷
arctan
sin
3
2
+
arcsin
cos
0
E
−
arccos

CONTENTS

INTRODUCTION

Most complex scientific and mathematical calculations can be handled with ease provided that the four basic arithmetic functions (+, −, ×, ÷) and eight transcendental functions (log and antilog, sin and arcsin, cos and arccos, tan and arctan) are readily available and can be incorporated in chain calculations.

The Sinclair Scientific offers all these facilities in a pocket calculator without adding a single key to the usual arithmetic calculator keyboard layout.

Because it provides general calculating capability of great power, rather than an accumulation of specialised functions, the Sinclair Scientific is an unusually versatile machine. At one level it is a substitute for a slide rule and mathematical tables which is both faster and more convenient to use; with its separate exponent, ranging from −99 to +99, it is also capable of carrying out chain calculations of unlimited length.

Although it was designed primarily for scientists and engineers, its price puts it well within the reach of students and schools and its power makes it invaluable for any commercial or industrial manager.

The Scientific is distinctive both in the way in which functions are used and in the format in which numbers are represented. All the twelve functions are used in a manner known as Polish notation which is easy to get used to and has considerable advantages in a scientific calculator.

Number representation and entry is in scientific notation which is fully explained in section 2.

Many functions, such as squaring and square roots, do not have separate keys on the keyboard devoted to them, but are obtainable from the other keyboard functions simply and quickly. These extra functions are part of the subject matter of section 6.

1. CONTROLS

On/Off

Always switch the calculator off when not in use, even if only for a few minutes. This will increase the battery life.

[C]

This key is used to clear the entire contents of the calculator.

[0] to [9]

The ten digits are used to enter numbers, including exponents.

[E]

The E key precedes the entry of the exponent part of a number.

[×] [÷] [+] [−]

The four function keys are for multiplication, division, addition and subtraction. [−] is also used to enter a negative exponent.

[▲] and [▼]

These function select keys, used in conjunction with the four functions keys, give the 8 trigonometric and logarithmic functions.

Key Sequence	Function
▲ ×	logarithm
▲ ÷	tangent
▲ +	sine
▲ —	cosine
▼ ×	antilogarithm
▼ ÷	arctangent
▼ +	arcsine
▼ —	arccosine

2. NUMBER REPRESENTATION AND ENTRY

Scientific Notation

If you are accustomed to working with a mantissa and exponent notation, you will find nothing strange in the method of entering numbers or reading the display of the Scientific—and you will know how convenient it is.

If you are not, you may find the following helpful.

Scientific and engineering calculations often employ positive or negative numbers of very large or very small magnitude. To avoid handling long strings of digits, these numbers are often represented by the first significant digits (the mantissa) and an exponent. The exponent tells you how many times the number as written has to be multiplied by ten to be the 'real' number.

Take 1¼ million. Expressed as 1,250,000 it is an unwieldy number to handle. To multiply it by 133 entails a sum like this:

$$\begin{array}{r} 1\,250\,000 \times \\ 133 \\ \hline 3\,750\,000 \\ 37\,500\,000 \\ 125\,000\,000 \\ \hline 166\,250\,000 \end{array}$$

Actually the calculation has used only the first 3 digits of 1250000—namely, 125. The strings of 0's are confusing, irrelevant and dangerous (since omitting one will throw out the whole calculation).

Now suppose we write 1250000 as 1.25×10^6 (in other words, 1.25—the mantissa—multiplied by 10 six times—the exponent). Then the sum is cut to its bare bones:

```
 1.25     (× 10^6)
  133
 ----
  375
 375
125
------
166.25    (× 10^6)
```

It is then extremely easy to multiply by 10 six times, simply by moving the decimal point six places to the right, thus:

166.250000 ⇒ 166,250,000.

133 can also be written in mantissa and exponent form, as 1.33×10^2. (1.33 ⇒ 133.)

The sum can now be written as:

```
 1.25     × 10^6
 1.33     × 10^2
 ----
  375
 375
125
------
1.6625    × 10^8 (the sum of the two
                  exponents)
```


This is how people who perform complex calculations with multi-digit numbers tend to work—calculating with the fewest possible digits, and simply keeping track of the exponent to indicate where the decimal point will finally be positioned.

And that is exactly what the Sinclair Scientific does.

Display Format

Numbers are represented with a signed, five-digit mantissa and a signed, two-digit exponent. The decimal point is fixed in position after the first digit of the mantissa, which is non-zero except in the case of 0.0000 00

For example:

3.5267—12 (representing 3.5267×10^{-12})
—4.8296 03 (representing —4829.6)
7.5093—01 (representing 0.75093)

Number entry

During number entry it is not necessary to enter a decimal point, it will automatically be inserted after the first digit. The entry of an exponent is optional and is done by using the E key, followed by — for a negative exponent. If no exponent is entered it will be assumed to be zero.

There are separate rules governing the entry of fractional and non-fractional numbers.

Entry of non-fractional numbers

When entering a number which is greater than 1 the first digit entered must be non-zero (i.e. the number must be entered in the same format as that in which it would be displayed).

Examples:

Number	Key Sequence
592	5 9 2 E 2
4.29	4 2 9
50	5 E 1

Entry of fractional numbers

When entering a number which is less than 1 the first digit entered must be 0 and the second non-zero.

Examples:

Number	Key Sequence
0.0037	0 3 7 E — 2
$.5673 \times 10^{-12}$	0 5 6 7 3 E — 1 2
6.7×10^{-3}	0 6 7 E — 2

The negative exponent entered is the number of 0's after the decimal point when the number is written without an exponent—0.0037 or 0.0067 in two of the above examples.

In many circumstances it is permissible to enter fractional numbers in alternative formats, e.g. 00037 for 0.0037. This subject is dealt with in detail in the Appendix.

The last two digits entered during exponent entry will be accepted. This enables an error made during exponent entry to be simply corrected. For example, if 4125E34 is intended and 4125E6 is entered, the mistake can be corrected and the entry completed by pressing 34.

3. FOUR FUNCTION ARITHMETIC

The four basic functions, ×, ÷, — and +, are used as Polish (post-fixed) operators. This means that when a key is pressed the corresponding function is carried out immediately, operating on the previous result and the new number which has just been entered. So, if a result has been obtained and it is to be divided by 7, press 7 ÷; if it is to be multiplied by 25, press 2 5 E 1 ×, and so on. Enter the new number and then the function which is to be applied to it and the previous result.

Before beginning a new sequence of calculation, the calculator should be cleared by using C. The first number is entered, followed by + or —, thereby adding or subtracting it from the previous result (0.0000 00, produced by C). When — is used the result is the entry of a negative number.

Examples:

(i) $18\left(\frac{4.5 - 3.2}{7}\right)$

Key Sequence	Display
C	0.0000 00
4 5 +	4.5000 00
3 2 —	1.3000 00
7 ÷	1.8571—01
1 8 E 1 ×	3.3427 00

(ii) $(0.326 - 0.583) \times 1.48 \times 10^7$

Key Sequence	Display
C	0.0000 00
0 3 2 6 +	3.2600—01
0 5 8 3 —	—2.5700—01
1 4 8 E 7 ×	—3.8036 06

4. TRANSCENDENTAL FUNCTIONS

There are eight transcendental functions directly obtainable from the keyboard. Logarithms, tangent, sine and cosine are obtainable by using the upper key, ▲, followed by ×, ÷, + and —, respectively. Antilogarithms, arctangent, arcsine and arccosine are obtained by pressing the lower key, ▼, then ×, ÷, + or —.

Like the four basic functions, the transcendental functions are used in a post-fixed mode. This means that the number should be entered before the appropriate function keys are used. If function keys are pressed without entering a new number the function will operate on the number in the display. (See the next section on chain calculations for further details.)

Logarithms and antilogarithms

Logarithms and antilogarithms are calculated directly to the base 10, but conversion to the base e, or any other base is simple.

The acceptable range of number for the logarithm function is from 1.0000 to 9.9999 $\times\ 10^{99}$. The maximum error is less than 0.0001.

Examples:

Key Sequence	Display	
1 ▲ × (log)	0.0000 00	log 1
3 6 ▲ ×	5.5634—01	log 3.6
7 1 E 4 ▲ ×	4.8512 00	log 71000
1 E 1 ▲ ×	1.0000 00	log 10

A natural logarithm (base e) is obtained by multiplying the result by $\log_e 10$ (2.30259), which is one of the conversion factors given on the calculator. For example $\log_e 5$ is given by

5 ▲ × 2 3 0 2 6 × Result: 1.6095 00

Note that 2.3026 has been used as an approximation to 2.30259. However, the internal capacity of the calculator is such that the full six-digit conversion factor could have been used.

The acceptable number range for the antilogarithm function (10^x) is from 0.0000 to 99.999. The maximum error is approximately 0.001.

Examples:

Key Sequence	Display	
0 ▼ × (antilog)	1.0000 00	10^0
0 5 ▼ ×	3.1621 00	$\sqrt{10}$
1 5 ▼ ×	3.1621 01	$10^{1.5}$
6 7 5 E 1 ▼ ×	3.1621 67	$10^{67.5}$

The exponential function (e^x) can be obtained, if required, by dividing the original number by $\log_e 10$ (2.3026). For example, $\sqrt{e}$ ($e^{0.5}$) is given by

C 0 5 + 23026 ÷ ▼ × Result 1.6486 00

Trigonometric functions

The Sinclair Scientific deals directly with angles expressed in radians, and a simple sum enables you to use these functions when working in degrees as well. The conversion factor used is 57.3 (a very close approximation to the 57.2958 given on the calculator). Examples are given below for both radians and degrees.

(i) Sine

The sine of angles between 0 and $\frac{\pi}{2}$ radians (0° and 90°) can be evaluated with an error of less than 0.001.

Examples:

Key Sequence	Display	
0 3 9 6 6 ▲ + (sin)	3.8629—01	sin 0.3966
0 9 2 4 1 ▲ +	7.9842—01	sin 0.9241
1 3 2 ▲ +	9.6891—01	sin 1.32
1 5 7 0 8 ▲ +	1.0000 00	sin 1.5708
C 4 5 + 5 7 3 ÷ ▲ +	7.0729—01	sin 45°
C 3 + 5 7 3 ÷ ▲ +	5.0003—01	sin 30°
C 9 + 5 7 3 ÷ ▲ +	1.0000 00	sin 90°

Note that in calculating the sine of 45°, 30°, and 90°, the angle has been entered as 4.5, 3.0 and 9.0—ten times too small in each case. This has, however, been compensated for by entering the conversion factor, 57.3, as 5.73 —also ten times too small. This illustrates a useful general rule, namely, when the exponents of two numbers which are to be divided are equal they may be omitted.

(ii) Cosine

The cosine of any angle between 0 and $\frac{\pi}{2}$ radians (0° and 90°) will be evaluated with a maximum error of approximately 0.001.

Examples:

Key Sequence	Display	
0 ▲ — (cos)	1.0000 00	cos 0
0 6 6 ▲ —	7.8994—01	cos 0.66
1 3 2 ▲ —	2.4802—01	cos 1.32
1 5 7 0 3 ▲ —	5.5000—04	cos 1.5703
C 4 5 + 5 7 3 ÷ ▲ —	7.0731—01	cos 45°
C 6 + 5 7 3 ÷ ▲ —	5.0008—01	cos 60°
C 0 8 + 5 7 3 ÷ ▲ —	9.9034—01	cos 8°

(iii) Tangent

The tangent of angles between 0 and $\frac{\pi}{2}$ radians (0° to 90°) can be evaluated. In the range from 0 to $\frac{\pi}{4}$ radians (0° to 45°) the error will be less than 0.001.

Examples:

Key Sequence	Display	
0 1 3 2 2 ▲ ÷ (tan)	1.3330—01	tan 0.1322
0 9 2 4 ▲ ÷	1.3250 00	tan 0.924
1 1 8 8 ▲ ÷	2.4850 00	tan 1.188
1 3 ▲ ÷	3.6046 00	tan 1.3
C 4 5 + 5 7 3 ÷ ▲ ÷	9.9990—01	tan 45°
C 3 + 5 7 3 ÷ ▲ ÷	5.7720—01	tan 30°
C 7 5 + 5 7 3 ÷ ▲ ÷	3.7197 00	tan 75°

(iv) Arcsine

The result is given in radians for values between 0 and 0.9995 with a maximum error of 0.001. The result can be converted to degrees by multiplying by 57.3.

Examples:

Key Sequence	Display	
Radians:		
0 3 1 2 5 ▼ + (asin)	3.1800—01	asin 0.3125
0 9 9 9 4 ▼ +	1.5350 00	asin 0.9994
Degrees:		
0 5 ▼ + 5 7 3 E 1 ×	2.9967 01	asin 0.5

(v) Arccosine

The result is given in radians for values between 0.001 and 0.9995 with a maximum error of 0.001.

Examples:

Key Sequence	Display	
Radians:		
0 3 ▼ — (acos)	1.2660 00	acos 0.3
0 9 6 ▼ —	2.8400—01	acos 0.96
Degrees:		
0 5 ▼ — 5 7 3 E 1 ×	6.0050 01	acos 0.5

(vi) Arctangent

The result is given in radians for values between 0 and 9.9999 with a maximum error of 0.001.

Examples:

Key Sequence	Display	
Radians:		
0 3 1 ▼ ÷ (atan)	3.0100—01	atan 0.31
3 ▼ ÷	1.2500 00	atan 3
Degrees:		
1 ▼ ÷ 5 7 3 E 1 ×	4.5038 01	atan 1

5. CHAIN CALCULATIONS

The transcendental functions may be used in the middle of a sequence of calculations, provided that they are applied to a partial result. For example:

C 3 + 2 × $\underbrace{▲ \times}_{\text{log}}$ will give the logarithm of 6

If a transcendental function is applied to a newly-entered number, a new sequence of calculation will begin and the previous result will be overwritten. For example:

C 3 + 2 × 5 $\underbrace{▲ \times}_{\text{log}}$ will produce 6, and then

the logarithm of 5. The result 6 has been overwritten and a new sequence of calculations begun. Note that, because the new sequence has begun with a transcendental function, it has not been necessary to use C to clear the previous result, as would have been the case if we had required 5 × 4 followed by 8 ÷ 3:

C 5 + 4 × C 8 + 3 ÷

The following examples show chain calculations in which the four basic functions and the transcendental functions are used together:

(i) $\log\left(\frac{(-3.82 + 22.6) \times 0.04}{0.0826}\right)$

Key Sequence	Display
C 3 8 2 —	—3.8200 00
2 2 6 E 1 +	1.8780 01
0 4 E — 1 ×	7.5120—01
0 8 2 6 E — 1 ÷	9.0944 00
▲ × (log)	9.5880—01

(ii) $10^{0.3} \times \sin(0.4455 - 0.032)$

C 0 4 4 5 5 +	4.4550—01
0 3 2 E — 1 —	4.1350—01
▲ + (sin)	4.0193—01
0 3 ×	1.2057—01
▼ × (antilog)	1.3199 00

(iii) $(4.5 \times \cos 1.3) + 7.89$

1 3 ▲ — (cos)	2.6737—01
4 5 ×	1.2031 00
7 8 9 +	9.0931 00

(iv) Arccos (log 982 — 2.0088)

9 8 2 E 2 ▲ × (log)	2.9921 00
2 0 0 8 8 —	9.8331—01
▼ — (arccos)	1.8300—01

6. TECHNIQUES

(i) Squaring and Doubling

If any of the basic four function keys is used without entering a new number, the function will multiply, divide, add or subtract the previous result from itself. If the result was A, this will produce the result A^2, 1.0000, 2A or 0.0000.

Example: $2 \times (3 + 5.2^2)$

Key Sequence	Display
C 5 2 +	5.2000 00
×	2.7040 01
3 +	3.0040 01
+	6.0080 01
—	0.0000 00

The final —, which was not a required part of the calculation, has caused the result to be subtracted from itself, and has exactly the same effect as using C in these circumstances.

(ii) Square roots and X^y

Here we use an extension of the method given in section 4 for e^x since x^y is an antilogarithm function, to the base x. Using the relationship $x^y = \text{alog}(y.\log_{10}x)$ we calculate the logarithm of x, multiply by y and calculate the antilogarithm of the product. In the case of obtaining a square root y is $\frac{1}{2}$ and the logarithm of x can be multiplied by 0.5 or divided by 2.

Examples:

(a)

$\sqrt{6}$

6 ▲ × (log)	7.7818—01
2 ÷	3.8909—01
▼ × (antilog)	2.4495 00 $\sqrt{6}$
×	6.0000 00

The final × has squared the result and provides a means of checking its accuracy.

(b)

$\sqrt[3]{\frac{47.6}{1.7}}$

4 7 6 E 1 +	4.7600 01
1 7 ÷	2.8000 01
▲ × (log)	1.4472 00
3 ÷	4.8240—01
▼ × (antilog)	3.0367 00

(c) $14.2^{3.08}$

Key Sequence	Display
1 4 2 E 1 ▲ × (log)	1.1523 00
3 0 8 ×	3.5492 00
▼ × (antilog)	3.5416 03

7. EXAMPLES

Financial

£4000 is invested at 9½% per annum.

What will the investment have grown to in 10 years 9 months?

$$4000 \times (1 + 0.095)^{10 \cdot 75}$$

Key Sequence

1 0 9 5 ▲ × (log)	3.9420—02
1 0 7 5 E 1 ×	4.2376—01
▼ × (antilog)	2.6529 00
4 E 3 ×	1.0611 04

Result: £10,611

Trigonometry

Find the area of a triangle having sides of 53 and 82 inches, enclosing an angle of 30°.

$$\text{Area} = \frac{a \times b \times \sin C}{2} = \frac{53 \times 82 \times \sin 30°}{2}$$

Key Sequence

C 3 + 5 7 3 ÷	5.2356—01	
▲ +	5.0003—01	sin 30°
5 3 E 1 × 8 2 E 1 × 2 ÷	1.0865 03	

Result: 1086.5 square inches

Inductance in a DC circuit

The coil of a relay has an inductance of .25 H and resistance of 100 ohms. If a steady voltage of 30 v is applied what is the time taken for the current to reach 50% of its maximum value?

$$\frac{i}{I} = 1 - e^{-Rt/L}$$

or

$$t = \frac{L \log_e\left(\frac{I}{i}\right)}{R}$$

Key Sequence

2 ▲ ×	3.0111—01	$\log_{10}\left(\frac{I}{i}\right)$
2 3 0 2 6 ×	6.9333—01	$\log_e\left(\frac{I}{i}\right)$
0 2 5 ×	1.7333—01	$L \log_e\left(\frac{I}{i}\right)$
1 E 2 ÷	1.7333—03	

Result: 1.73 msecs.

Transmission line tension

A twin wire aerial transmission line is supported on 15 ft. poles 150 ft. apart. A stay is attached to the terminal pole and anchored 9 ft. from the base. The sag at the centre of the span is 18 in. and the weight of the wire is 0.992 lbs/ft.

What is the tension in the stay?

$$t_{stay} = \frac{t_{horiz}}{\sin \Theta}$$

$$\Theta = \arctan (15/9) \quad t_{horiz} = \frac{wl^2}{8s}$$

Key Sequence

C 1 5 E 1 ÷ 9 ÷	1.6666 00	15/9
▼ ÷	1.0310 00	arctan (15/9)
▲ +	8.5817—01	$\sin \Theta$
C 1 5 E 2 ÷ ×	2.2500 04	l^2
0 9 9 2 E —1 ×	2.2320 03	wl^2
8 ÷	2.7900 02	$wl^2/8$
1 5 ÷	1.8600 02	$wl^2/8s$
0 8 5 8 1 7 ÷	2.1674 02	

Result 217 lb.

Amplifiers

The power output from an amplifier is increased from 2 to 5 watts. What is the change in level in decibels?

$$N = 10 \log_{10}\left(\frac{P_2}{P_1}\right)$$

Key Sequence

C 5 ÷ 2 ÷	2.5000 00	$\frac{P_2}{P_1}$
▲ ×	3.9800—01	$\log_{10}\left(\frac{P_2}{P_1}\right)$
1 E 1 ×	3.9800	$10 \log_{10}\left(\frac{P_2}{P_1}\right)$

Result: 3.98 db

8. BATTERIES

The Sinclair Scientific Calculator uses four dry-cells, Mallory MN 2400, or any U16 sized cells (sometimes known as "AAA" size). These cells are available from most chemists, radio and electrical shops.

The MN 2400 batteries will give about 25 hours of use under the most severe conditions of continuous operation and with all segments of the display permanently on; with normal usage, the battery life will be significantly longer, but it is important to switch your calculator off between calculations to conserve battery life.

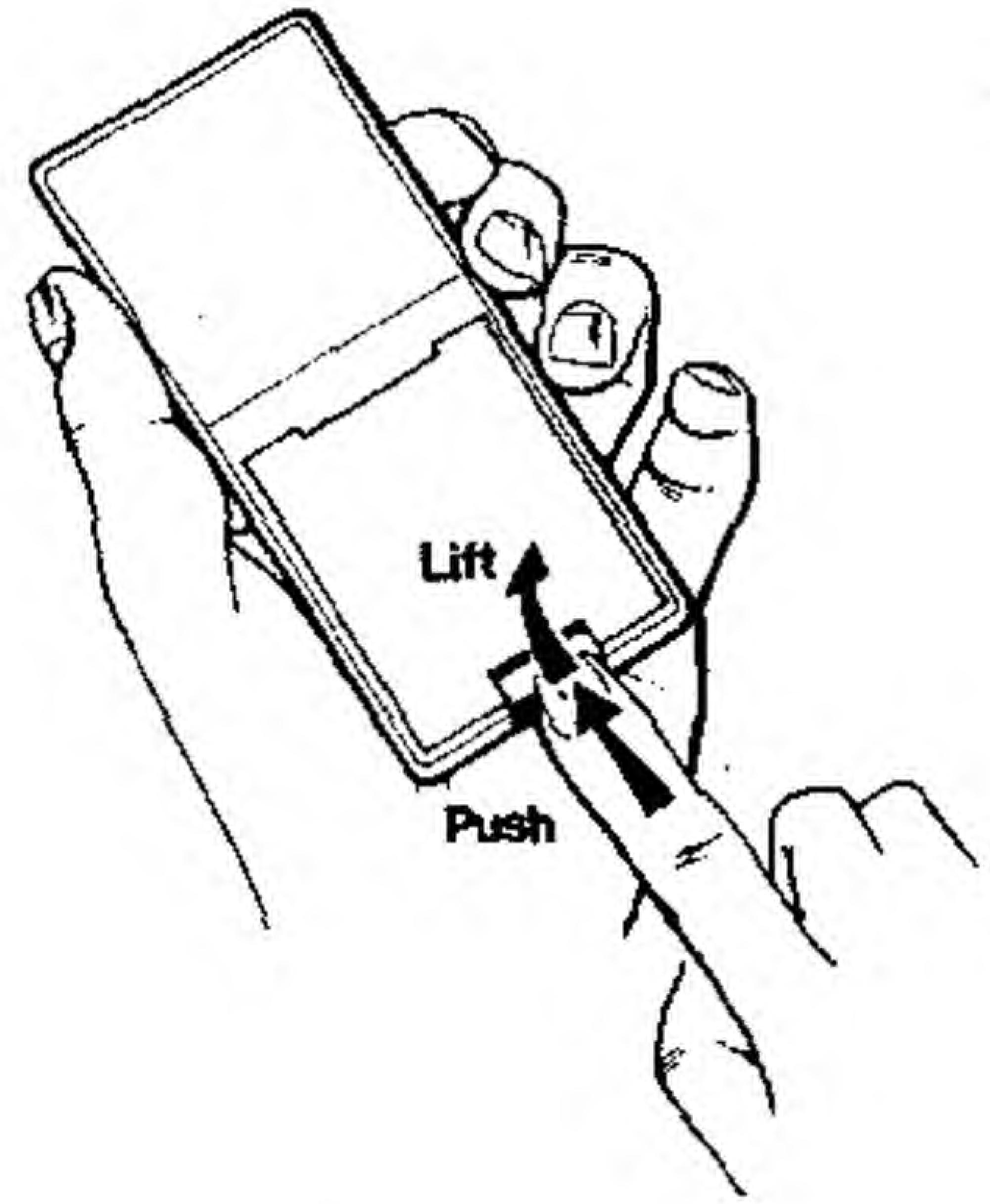
Whilst it is possible to use U16 cells, these should not be left in the calculator for long periods—also they will give a shorter operational life.

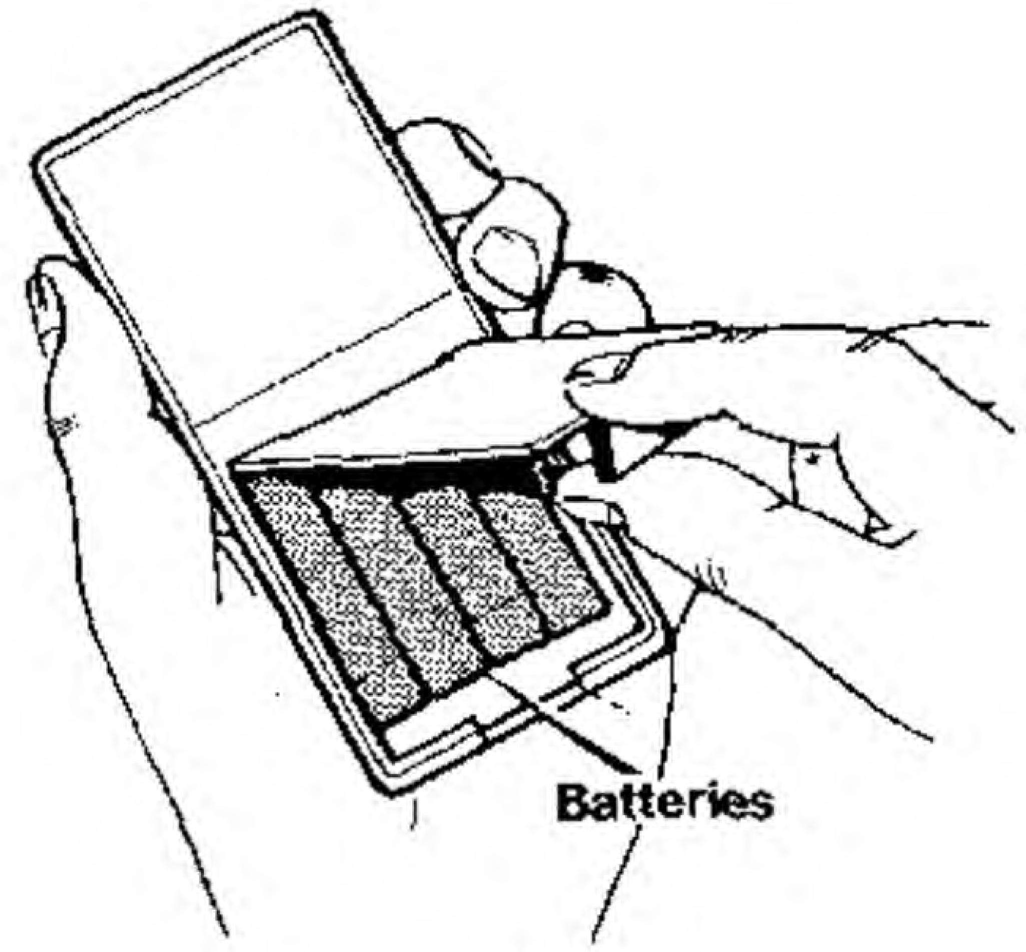
When changing the cells it is most important to replace a complete set at any one time.

Indication of failing batteries will be given by a fading of the display. It is possible for calculations to be affected if batteries are too flat, so it is wise to replace batteries as soon as any dimming in the calculator's displays is noticed.

Batteries are replaced through the removable cover in the bottom of the calculator. Al-

though reversal will not damage the calculator, batteries must be fitted the right way round or the calculator will not work. This is shown in the diagrams on the opposite page.





CARE OF YOUR CALCULATOR

If your calculator remains unused for a long period of time, especially in a hot or humid climate, it is possible for a thin film of oxide to form underneath the keyboard plate, causing incorrect number entry. This film can be cleared simply by pressing each key, firmly, once.

APPENDIX

There are few circumstances in which one would wish to enter a non-fractional number with a leading zero, but if it is required to enter, say, 67.2 as 0 6 7 2 E 2 rather than the more usual 6 7 2 E 1, then it will rarely cause a problem. However, this format is not acceptable to the logarithm function, and a loss of accuracy may occur if more than one leading zero is entered in a mantissa prior to the multiplication function.

As far as fractional numbers are concerned, there are circumstances in which you might want to depart from the normal format of a leading zero and non-zero second digit in the mantissa. If the leading digit is non-zero and the exponent decremented by one—for example 63E—3 instead of 063E—2—there is little chance of any problem arising. In fact, the only situation where this entry format for a fractional number would not be acceptable is immediately before a multiplication where the previous result, by which it is to be multiplied, has an exponent which is of the same magnitude but positive, and where the result would be greater than 10.

If more than one leading zero is entered in a fractional number, for example 0.003 is entered as 0003 instead of 03E—2, then as for non-fractional numbers a loss of ac-

curacy may occur if the following function is multiplication. In other cases, the format is acceptable.

Internally, the calculator has a capacity to accept and work with six digits in the mantissa. For example, to add 3.12698 and 4.56217 the operations required are as follows:

C 3 1 2 6 9 8 +	3.1269 00
4 5 6 2 1 7 +	7.6891 00
7 —	6.8915—01

The last step has removed the most significant digit of the mantissa, 7, and revealed the sixth and least significant, 5. The full result is therefore 7.68915.